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THE EFFECT OF VARIOUS WING-GUN INSTALLATIONS ON THE AERODYNAMIC CHARACTERISTICS OF AN AIRPLANE MODEL EQUIPPED WITH AN NACA LOW-DRAG WING

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SUMMARY

An investigation was made in the NACA 19-foot pressure wind tunnel to determine the effect of various wing-gun installations on the aerodynamic characteristics of a model with an NACA low-drag wing. Measurements were made of lift and drag over an angle-of-attack range and for several values of dynamic pressure on a four-tenths scale model of a high-speed airplane equipped with the low-drag wing and with various wing-gun installations.

Two installations were tested: one in which the blast tube and part of the gun barrel protrude ahead of the wing and another in which the gun is mounted wholly within the wing. Two types of openings for the latter installation were tested. For each installation three simulated guns were mounted in each wing.

The results are given in the form of nondimensional coefficients. The installations tested appear to have little effect on the maximum-lift coefficient of the model. However, the drag coefficient shows a definite change. The least adverse effect was obtained with the completely internal mounting and small nose entrance. The results indicate that a properly designed wing-gun installation will have very little adverse effect on the aerodynamic characteristics of the low-drag wing.

INTRODUCTION

In the light of recent military findings, an increase in fire power of fighter-type airplanes is highly desirable. The procedure in the past has been to mount the guns on the fuselage; however, the addition of still more guns necessitates the mounting of some of these guns in the wings because of space limitations in the fuselage. Further, the increasing use of explosive projectiles requires that the guns be mounted outside of the propeller arc in order to prevent the damage that would result from a collision between a propeller blade and an ill-timed shot. Therefore this type of gun, firing forward, must necessarily be mounted on, or in, the wings of conventional tractor-propelled airplanes.

For a minimum of disturbance to the flow about the wing, it is obvious that a gun mounted inside the wing itself and firing through an opening in the leading edge would give the best results. Lately, the possibilities of utilizing the NACA low-drag airfoil sections have created a great deal of interest in the effect wing-gun installations would have on the characteristics of these airfoils.

In order to supply some information quickly along the foregoing lines, the present short series of tests was made to determine the effect on the model characteristics of two types of internal wing-gun blast tubes and one type of installation in which the blast tube along with part of the gun barrel protrudes ahead of the wing. All the tests were conducted on a four-tenths scale model of a current type of high-performance military airplane equipped with an NACA low-drag wing.

MODEL AND TESTS

The model used in these tests was a four-tenths scale model of a high-speed pursuit airplane. (See fig. 1.) The model has an NACA low-drag wing, small fuselage, tail, and NACA cowling. In addition, the model has various surface roughnesses to simulate the surface joints of the landing gear, canopy hatches, inspection doors, control-surface gaps, etc. The model with this arrangement and with the surface in a highly polished condition was used as the basis for comparing the various gun installations, and will be designated the "basic condition" throughout this paper.

In a number of wing-gun installations a portion of the blast tube and the gun barrel protrude forward from the leading edge of the wing. To test the effects of this method of mounting, three wooden dowels, designed to simulate the protruding parts, were inserted in the leading edge of each wing outboard of the fuselage and in the same relative position as actual guns on a full-scale airplane. (See figs. 2 and 3.)

The trend of current practice, however, is to mount the guns wholly within the wing so that the forward tip of the barrel is some distance behind the leading edge of the wing. To test this method of installation, three holes were drilled in each wing, as shown in figure 4, to simulate the internal blast-tube system. Two of these holes connected with the third which in turn exhausted all the air onto the upper surface of the wing about 0.60c behind the leading edge. In order to find the effect of entrance shape on the characteristics, two different types of openings were tested. These different openings were made in inserts which were fastened into the front end of the ducts.

Type A opening (see figs. 5 and 6) was designed to have the theoretical minimum adverse effect. The frontal area of this opening, 0.201 square inch, is the same as the free circular area between the outside of the gun barrel and the inside of the blast tube scaled down to model size. The area of the exit hole (see fig. 7) on the upper surface of the wing was equal to the sum of the areas of the three entrances. Type A opening was tested with and without air flow, the exit hole being closed and faired smooth with the upper surface of the wing for this latter condition.

The second entrance tested, type B, shown in figures 8 and 9, was merely a circular passage, 1 inch in diameter, leading back to a point 1 7/8 inches aft of the leading edge where a circular constriction was formed. The area of this constriction was 0.201 square inch, the same as the entrance area of the type A opening. Type B opening was tested only for the condition of air flowing.

For the basic condition and for each of the different gun installations, a series of runs was made. Each series consisted of complete lift-drag polars at dynamic pressures of 25 and 50 pounds per square foot and lift-drag measurements over an angle-of-attack range from -2° to 4° at values of dynamic pressure of 25, 50, 100, and 150 pounds per square foot.

RESULTS

All data are presented in nondimensional coefficient form corrected for jet-boundary interference and model support tare.

The symbols used herein are defined as follows:

α angle of attack of root chord corrected for jet-boundary interference

C_L lift coefficient, L/qS

C_D drag coefficient, D/qS

S wing area (42.83 sq ft)

q dynamic pressure in the undisturbed air stream ($1/2\ \rho V^2$), pounds per square foot

ρ air density, slugs per cubic foot

V velocity of the air, feet per second

c mean chord (2.68 ft)

b wing span (16 ft)

The coefficients of the model in the basic condition are used as the basis for comparing the effects of various gun installations. For this condition the complete curves of lift and drag against angle of attack for one value of dynamic pressure are given in figure 10.

The effect on maximum lift of the various gun installations, as compared with the basic condition, was determined. From the results obtained, it appears that none of the arrangements are detrimental to the maximum lift, the variations being close to the experimental accuracy of measurement.

The curves of variation of drag coefficient with lift coefficient through the low-lift range for the different gun installations and for the basic condition are given in figures 11 to 15, inclusive. The deviation of the curves for the gun installations from that of the basic condition is very small, the greatest deviation resulting from the use of type B entrance.

Figure 16 gives the variation of drag coefficient at

$C_L = 0.1$ with Reynolds number for the basic condition and each of the gun installations.

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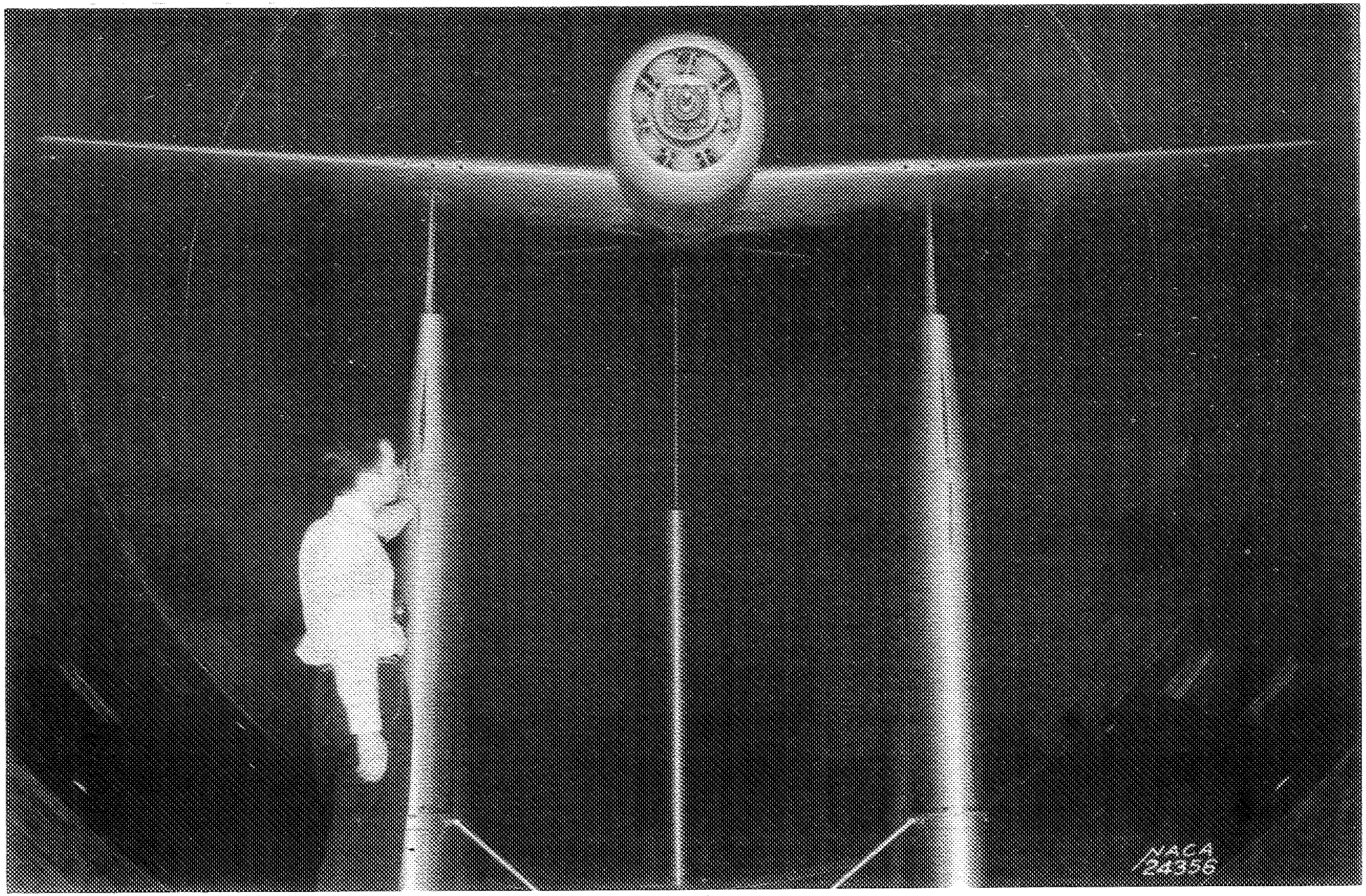


Figure 1.- Front view of the 0.4 - scale model airplane mounted on the standard supports in the 19 - foot pressure wind tunnel.

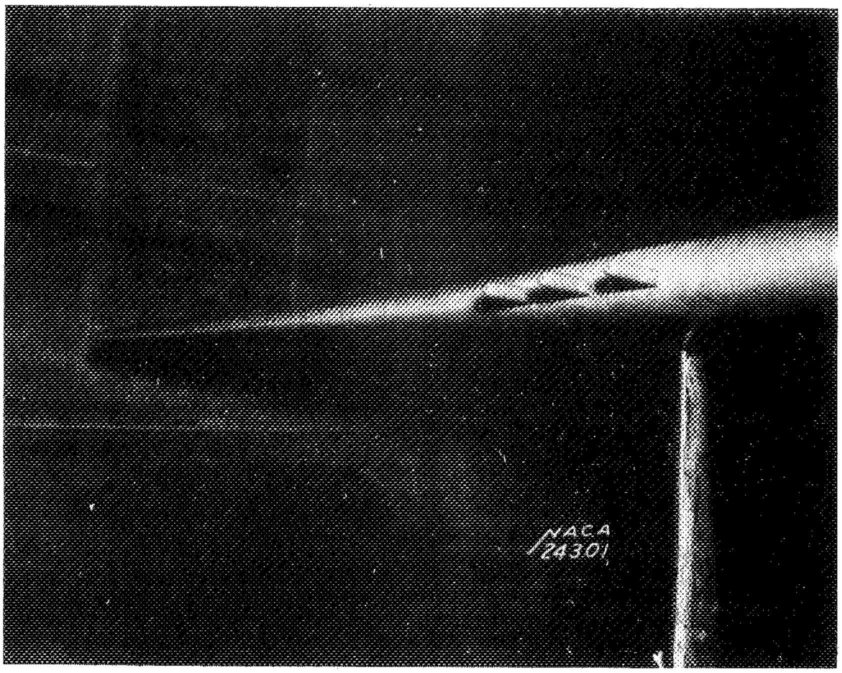


Figure 2.- Three-quarters view of simulated protruding gun installation mounted in leading edge of wing.

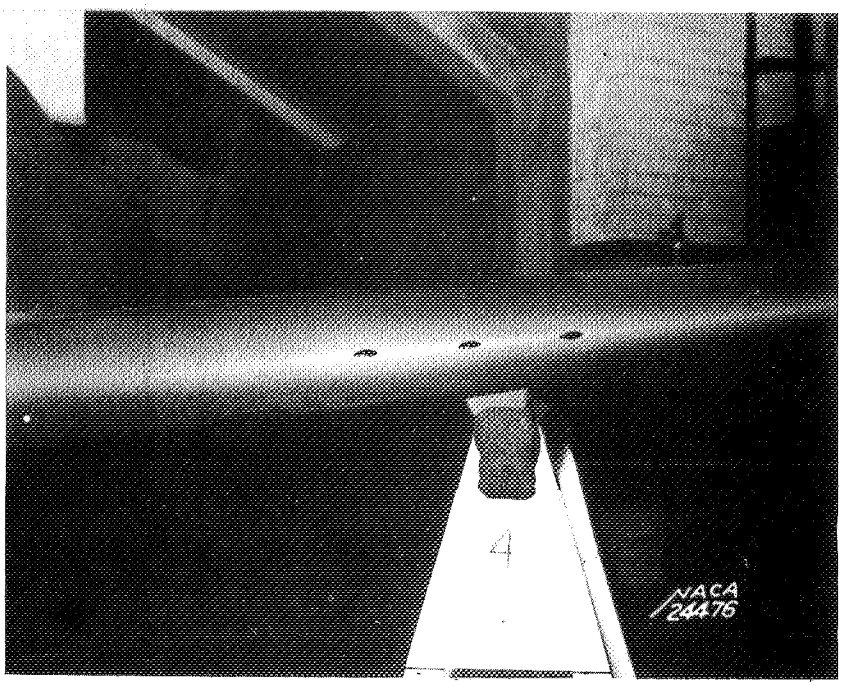


Figure 6.- Type A wing gun blast tube entrance.

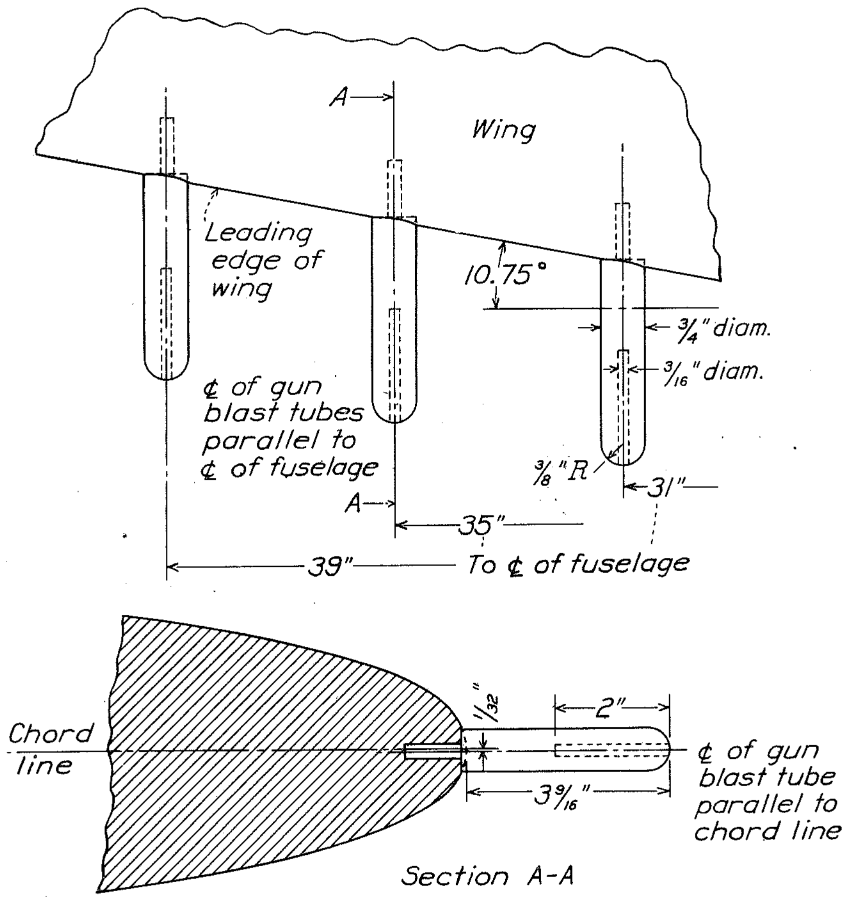


Figure 3.- Details of simulated protruding wing gun installation.

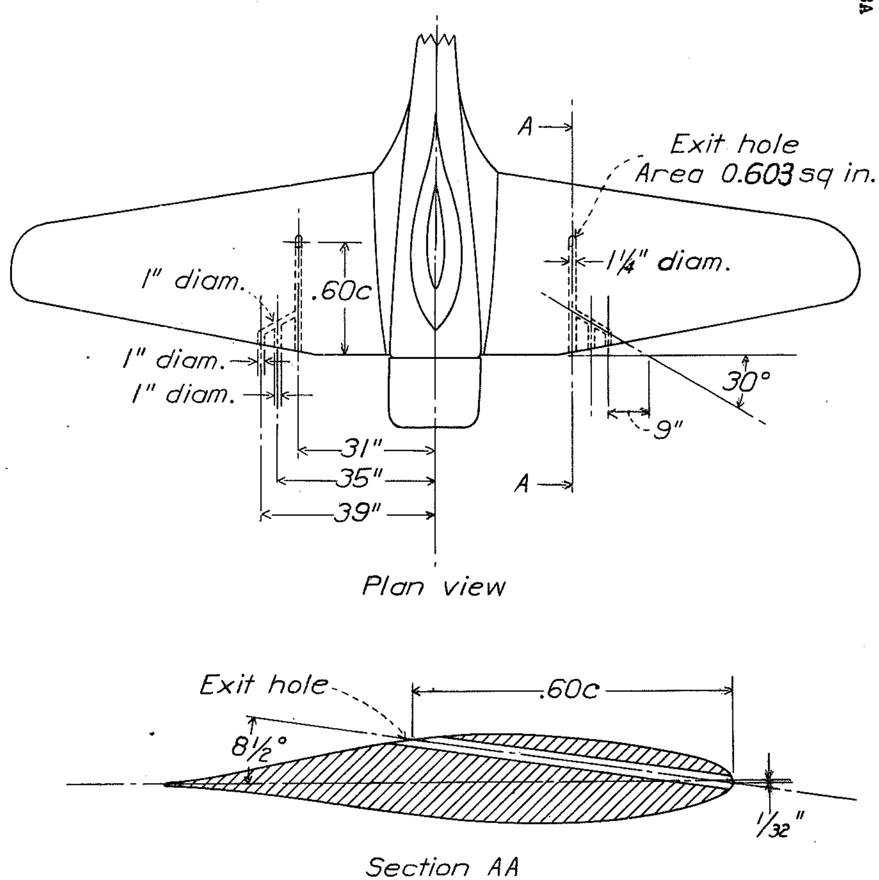


Figure 4.- Duct system to simulate flow through internal wing gun blast tubes.

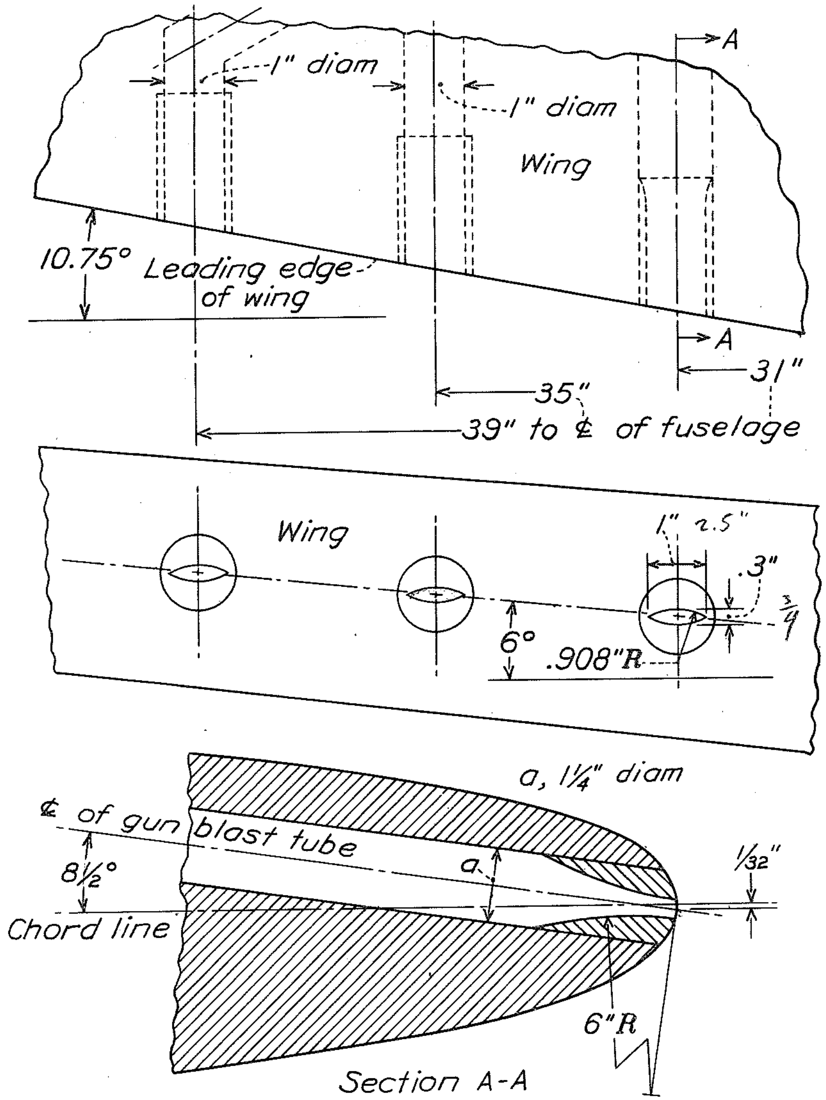


Figure 5.- Details of type A duct entrance for wing gun installation.

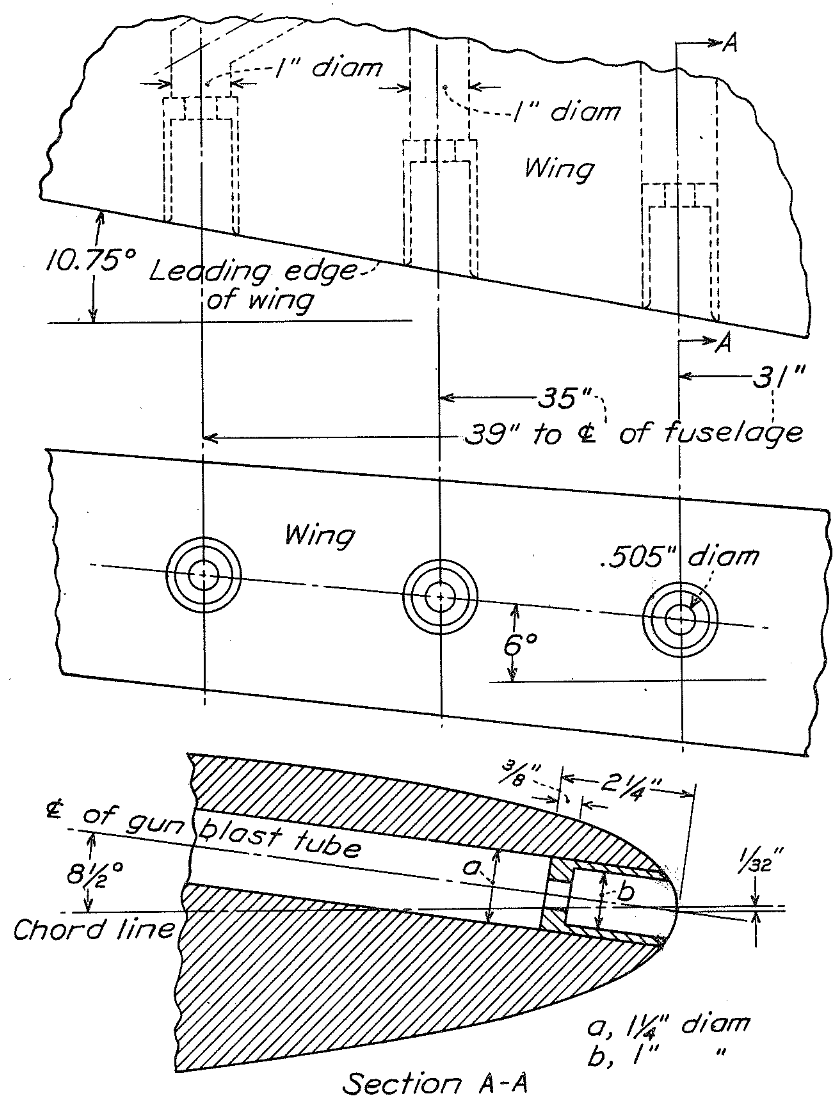


Figure 8.- Details of entrance type B of internal wing gun installation.

Figure 7.- Close-up of exit opening for wing gun duct system.

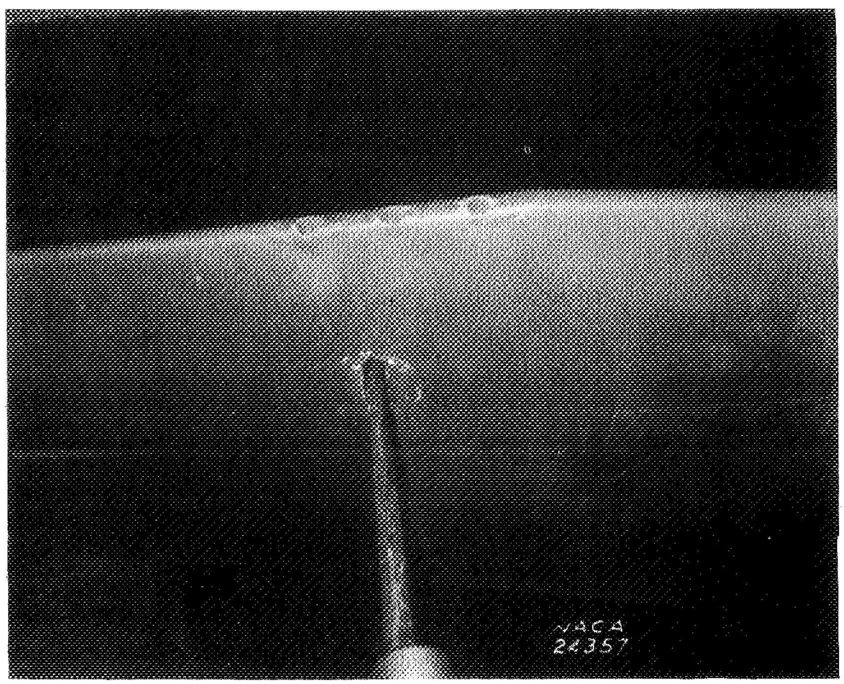
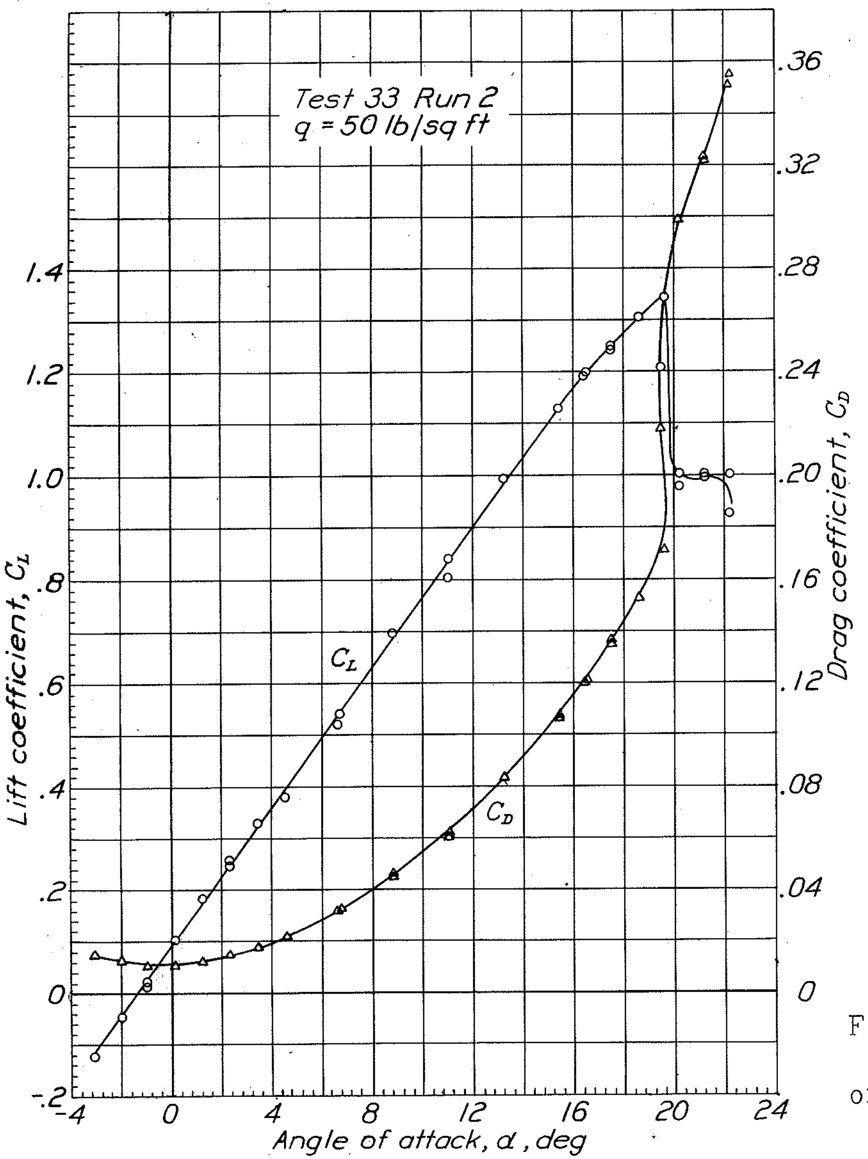


Figure 9.- Close-up of type B wing gun blast tube entrance.



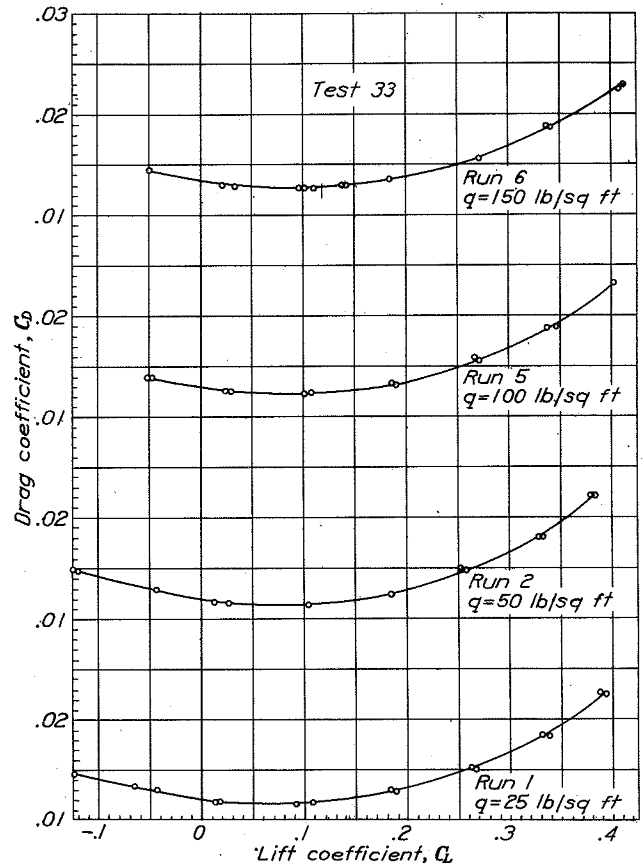


Figure 11.- The variation of drag coefficient with lift coefficient for the basic model condition.

Figure 10.- The variation of the lift and drag coefficients with angle of attack for the basic model condition.

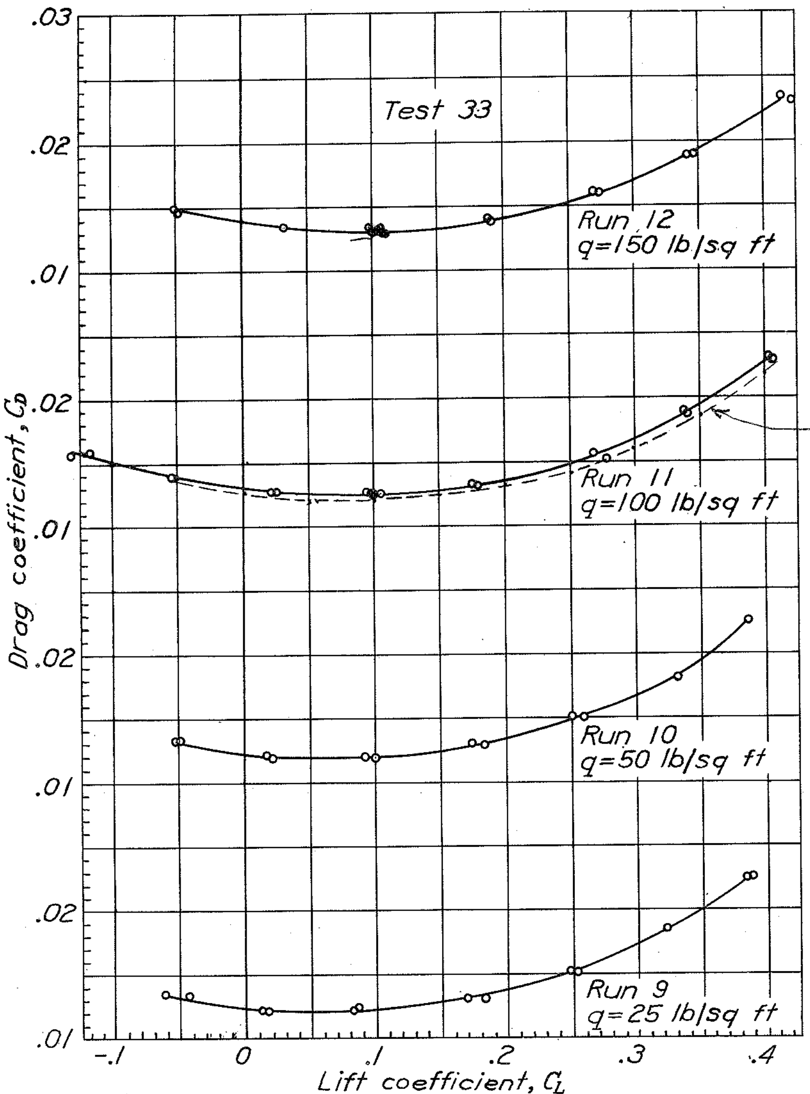


Figure 12.- The variation of drag coefficient with lift coefficient for the protruding wing gun installation.

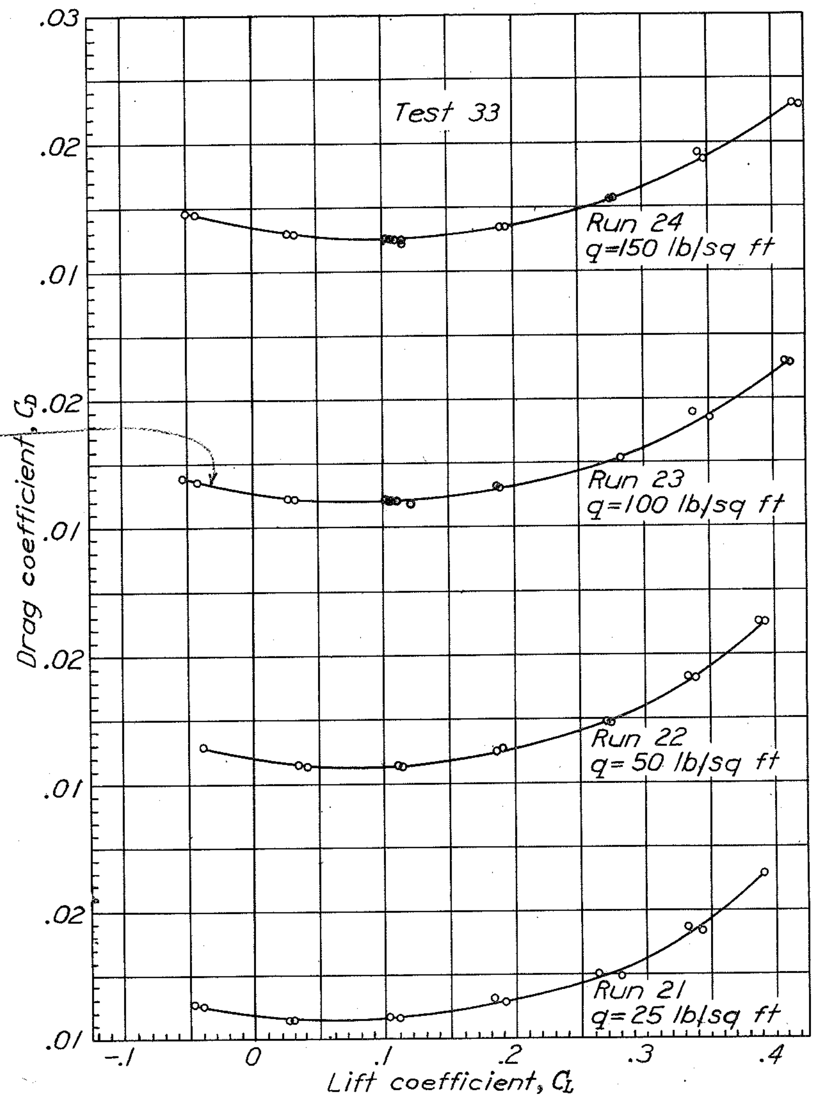


Figure 13.- The variation of drag coefficient with lift coefficient for type A internal gun installation with airflow.

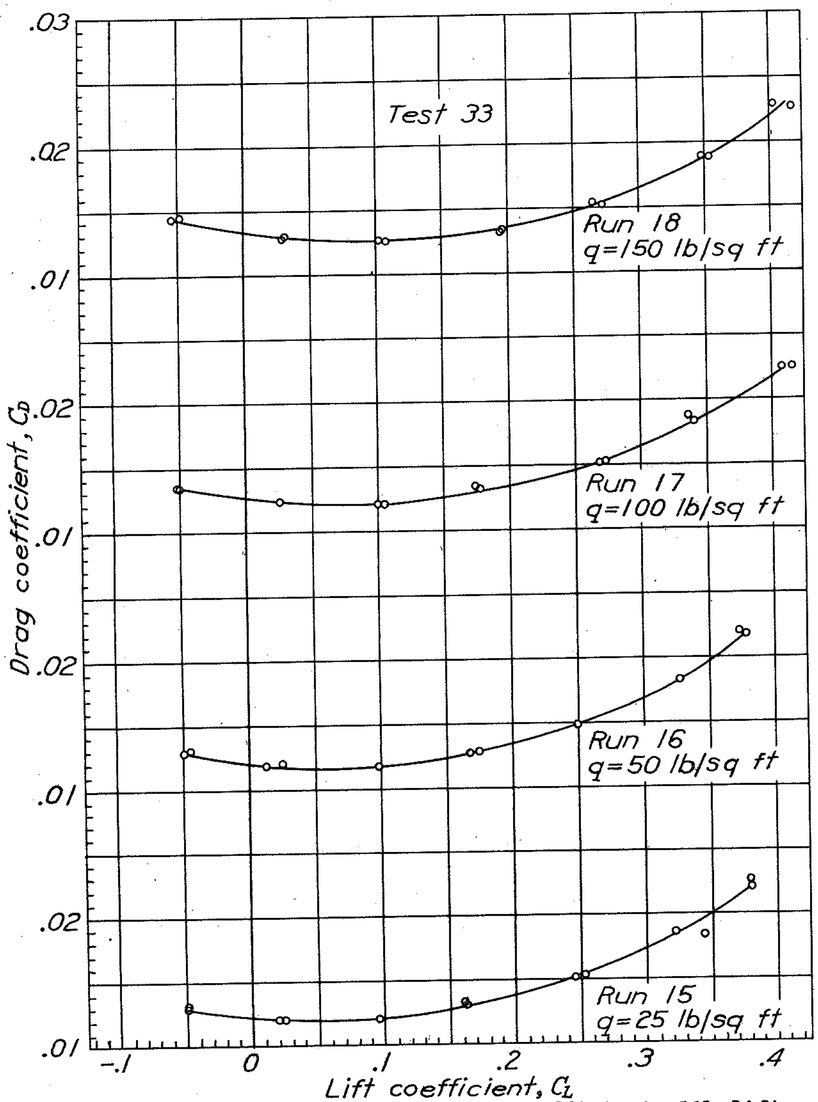


Figure 14.-The variation of drag coefficient with lift coefficient for type A internal gun installation without airflow.

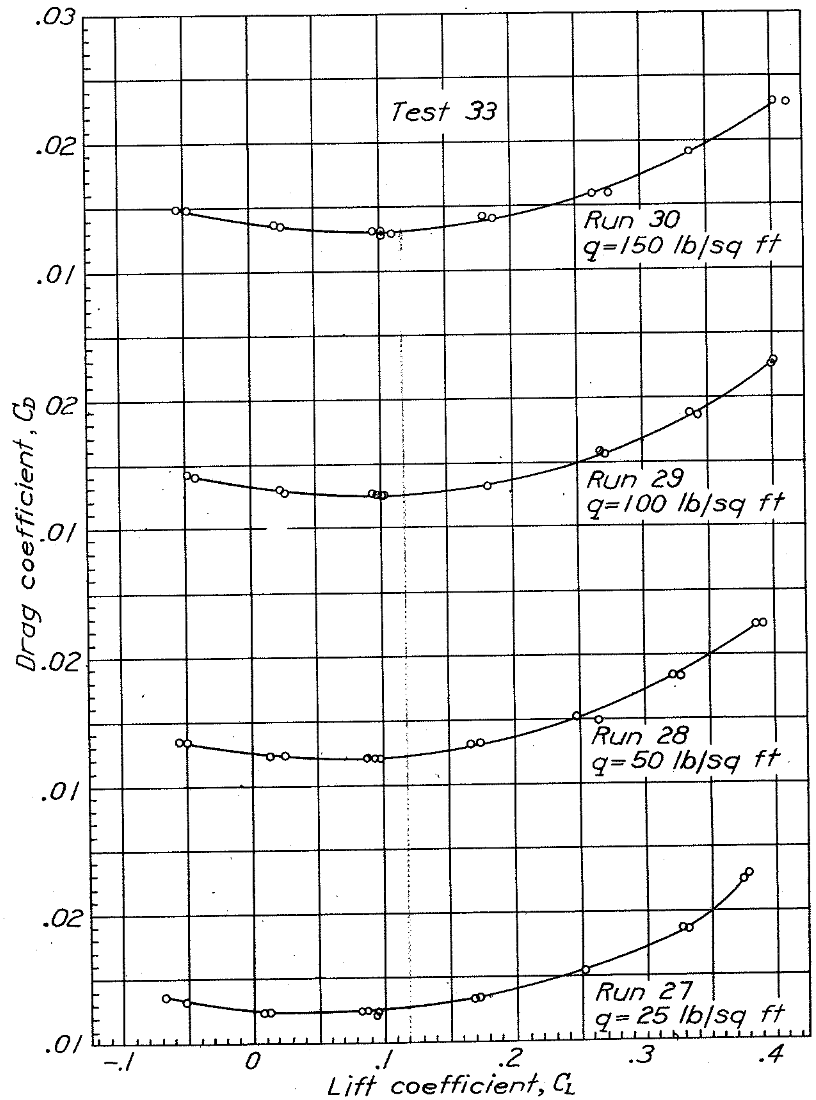


Figure 15.- The variation of drag coefficient with lift coefficient for type B internal gun installation with air flow.

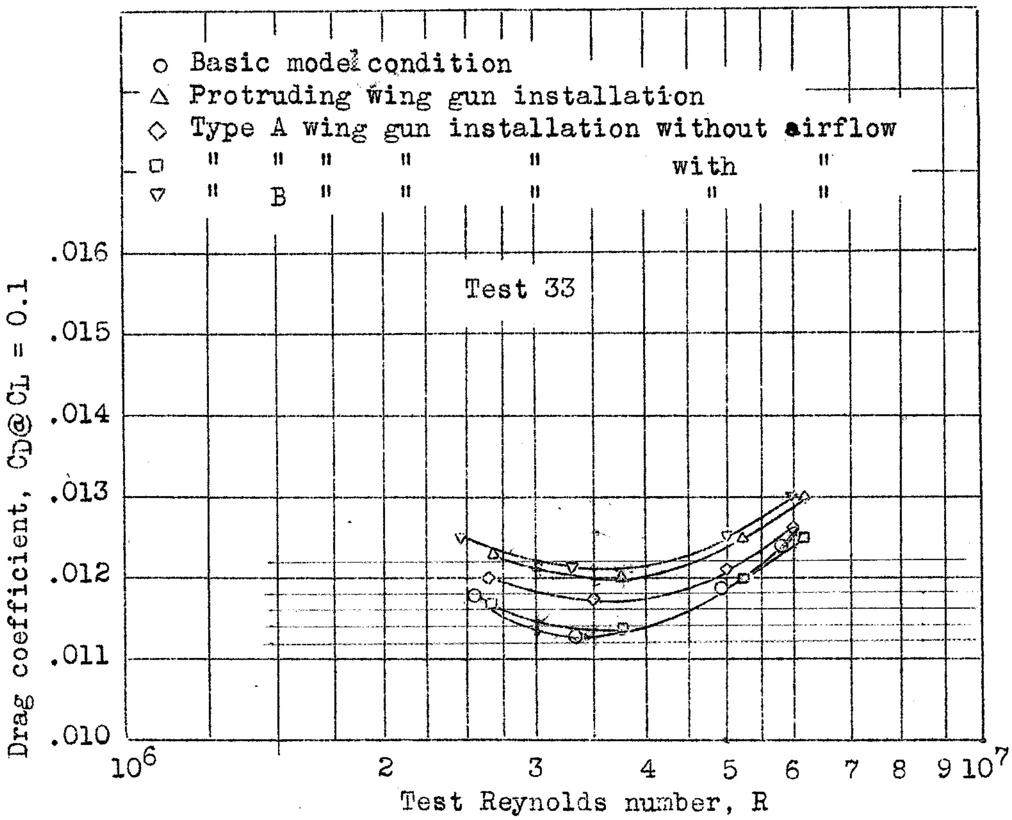


Figure 16.- The variation of drag coefficient at C_L = 0.1 with Reynolds number for the basic model condition and with various wing gun installations.